Machine-Assisted English Translation of JP 10-148729 Provided by JPO

PATENT ABSTRACTS OF JAPAN

(11)Publication number : 10-148729
(43)Date of publication of application : 02.06.1998

(51)Int.Cl. G02B 6/13

(21)Application number : 08-310959
(22)Date of filing : 21.11.1996

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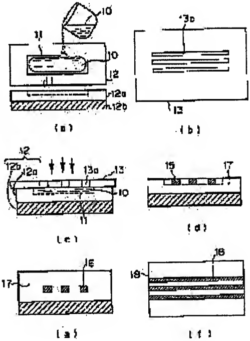
(54) FORMATION OF RIDGE PATTERN OF CORE PART OF POLYMER OPTICAL WAVEGUIDE

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a method for forming ridge pattern of the core part of polymer optical waveguide which is simple, excellent in mass productivity, and allows easy execution of the connection to optical parts.
SOLUTION: This method consists of previously forming a liquid reserving 11 pool in the part to be formed with the high-polymer optical waveguides and injecting a liquid photosensitive material into the liquid reserving 11 pool. The liquid photosensitive material injected into the liquid reserving pool is photoirradiated through a mask 13 formed with the prescribed ridge patterns 15, by which pattern latent images are formed. The unirradiated parts of the photosensitive material are removed by using a solvent after the formation of the pattern latent images. The remaining parts of the photosensitive material are formed as the core part 17 for guiding of light in the stage for removal by the solvent.



LEGAL STATUS

[Date of request for examination]	25.10.2000
[Date of sending the examiner's decision of rejection]	29.11.2002
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]	
[Date of final disposal for application]	
[Patent number]	
[Date of registration]	
[Number of appeal against examiner's decision of rejection]	
[Date of requesting appeal against examiner's decision of rejection]	
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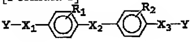
CLAIMS

[Claim(s)]
[Claim 1] The process which forms a sump pool in the part which is an approach for forming the ridge pattern corresponding to the core section of giant-molecule optical waveguide, and should form giant-molecule optical waveguide beforehand, The process which pours the liquefied photosensitive matter into this sump pool, and the process which carries out an optical exposure through the mask with which the predetermined ridge pattern was formed to the liquefied photosensitive matter poured into said sump pool, and forms a pattern latent image, It has the process which removes the non-irradiated part of said photosensitive matter using a solvent after this pattern latent-image formation. Furthermore, the ridge pattern formation approach of the giant-molecule optical waveguide core section characterized by considering as the core section for light guiding the part into which said photosensitive matter remained at the process of removal by said solvent.
[Claim 2] The process which forms the slot for installing an optical fiber in the position of said sump pool after the process which is an approach according to claim 1 and forms said sump pool beforehand, It has further the process which performs alignment of said liquefied photosensitivity matter poured in to said sump pool after the process which pours the liquefied photosensitive matter into said sump pool, and said optical fiber put on said slot. The ridge pattern formation approach of the giant-molecule optical waveguide core section characterized by making optical connection of said core section with the core section of said optical fiber.
[Claim 3] The process which forms the slot for installing a microoptics component in the position of said sump pool after the process which is an approach according to claim 1 and forms said sump pool beforehand, It has further the process which performs alignment with the microoptics component put on the liquefied photosensitive matter poured in to said sump pool after the process which pours the liquefied photosensitive matter into said sump pool, said V groove, or the rectangle slot. The ridge pattern formation approach of the giant-molecule optical waveguide core section characterized by making optical connection with said core section and said microoptics component.
[Claim 4] It is the ridge pattern formation approach of the giant-molecule optical waveguide core section characterized by being an approach according to claim 3 and choosing said microoptics component from the group which consists of laser diode (LD), light emitting diode (LED), light-receiving diode (PD), a filter, a lens, a mirror, a diffracted-light child, and a polarizing element.
[Claim 5] It is the ridge pattern formation approach of the giant-molecule optical waveguide core section which is an approach given in claim 1 thru/or any 1 term of 4, and is characterized by said liquefied photosensitive matter consisting of reactant oligomer and a photopolymerization initiator.
[Claim 6] Liquefied reactant oligomer according to claim 4 is a general formula (1).
[Formula 1]

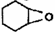


(1)

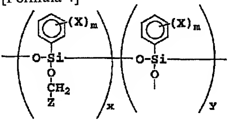
(2 R1, R 2 showing a hydrogen atom, a halogen atom, an alkyl group, an alkoxy group, or a

trifluoromethyl radical independently, respectively. X1, X X expressing among a formula the connection radical which 3 contains the alkyl group, the alkyl ether radical, and the ring, and contains the OH radical of a piece at least. Y polymerization ****** [Formula 2])

Or [Formula 3]



The ridge pattern formation approach of the giant-molecule optical waveguide core section characterized by being the epoxy system oligomer expressed with ******.
[Claim 7] It is an approach according to claim 4, and said liquefied reactant oligomer is a general formula (2).
[Formula 4]



(2)

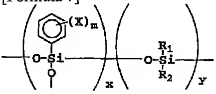
(X expresses a hydrogen atom, a heavy hydrogen atom, a halogen atom, an alkyl group, and an ARUKOSHIKI radical among a formula, and m expresses the integer of 1-4.) Z is an epoxy group shown in the following type (I) or (II), and is [Formula 5].

(I)

[Formula 6]

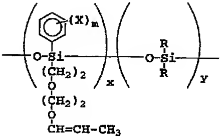
(II)

the inside of a formula, x, and y -- the abundance of each unit -- being shown -- y -- x -- small -- 0 -- you may be -- the ridge pattern formation approach of the giant-molecule optical waveguide core section characterized by being the liquefied silicone epoxy system oligomer expressed.
[Claim 8] It is an approach according to claim 4, and said liquefied reactant oligomer is a general formula (3).
[Formula 7]



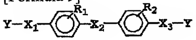
(3)

(X expresses a hydrogen atom, a heavy hydrogen atom, a halogen atom, an alkyl group, and an alkoxy group among a formula, and m expresses the integer of 1-4.) x and y show the abundance of each unit and x and y are not 0. R1 and R2 a methyl group, an ethyl group, and an isopropyl group -- expressing -- R1 R2 a phase -- being equal -- the ridge pattern formation approach of the giant-molecule optical waveguide core section characterized by being the liquefied silicone system oligomer expressed.
[Claim 9] It is an approach according to claim 4, and said liquefied reactant oligomer is a general formula (4).
[Formula 8]



(4)

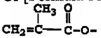
(X expresses a hydrogen atom, a heavy hydrogen atom, a halogen atom, an alkyl group, and an alkoxy group among a formula, and m expresses the integer of 1-4.) x and y show the abundance of each unit and x and y are not 0. R -- a methyl group, an ethyl group, and an isopropyl group -- expressing -- the ridge pattern formation approach of the giant-molecule optical waveguide core section characterized by being the liquefied silicone vinyl ether oligomer expressed.
[Claim 10] Liquefied reactant oligomer according to claim 4 is a general formula (5).
[Formula 9]



(5)

(2 R1, R 2 showing a hydrogen atom, a halogen atom, an alkyl group, an alkoxy group, or a truffe ROORO methyl group independently, respectively. X1, X X 3 containing the alkyl group, the alkyl ether radical, and the ring, and expressing a connection radical among a formula. Y polymerization ****** [Formula 10])

Or [Formula 11]



The ridge pattern formation approach of the giant-molecule optical waveguide core section characterized by being the acrylic oligomer of ******.

[Translation done.]

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention is available to the various optical waveguides and the optical integrated circuit which are used in general optics, the microoptics field, the optical-communication field, and the optical-information-processing field, an optical patchboard, etc., and relates to the ridge pattern formation approach of the giant-molecule optical waveguide core section especially about the optical waveguide using polymeric materials.
[0002]
[Description of the Prior Art] Generally, it is easy to thin-film-ize polymeric materials with a spin coat method, a dip method, etc. Therefore, polymeric materials are known from the former as a suitable ingredient to produce the optical waveguide of a large area. Moreover, when using polymeric materials, since the heat treatment process in an elevated temperature is not needed on the occasion of membrane formation, compared with the case where inorganic glass ingredients, such as a quartz, are used, there is an advantage that heat treatment in an elevated temperature can produce optical waveguide for a semi-conductor substrate, a plastic plate, etc. on a difficult substrate. Furthermore, production of the flexible optical waveguide which harnessed the flexibility and tough nature of a giant molecule is also possible. It is expected that optical waveguide components, such as an optical integrated circuit used in the field of optical communication and an optical patchboard used in the field of optical information processing, can be manufactured in large quantities and cheaply from such a thing using polymeric materials.
[0003] Conventionally, it has been supposed that there is a problem the polymeric materials applied to the optical field in respect of resistance tos environment, such as thermal resistance or moisture resistance. However, the ingredient which raised thermal resistance by including aromatic series radicals, such as the benzene ring, in recent years or using an inorganic polymer is reported (for example, JP,3-43423,A). Thus, since it has that thin film formation is easy for polymeric materials and not needing high temperature processing on the occasion of membrane formation, and the advantage that troubles further, such as thermal resistance and moisture resistance, are also being improved, the attempt used for creation of optical waveguide is made.
[0004] As the creation approach of optical waveguide which consists of polymeric materials the photograph locking which is made to contain a monomer in polymeric materials, is made to react with a monomer by optical exposure, and makes a refractive-index difference with a non-irradiating part, or a selection photopolymerization method (Kurokawa et al. --) application (Imamura et al. --) of the approach of using for semi-conductor processings, such as 17 applied optics 646 pages, 1978 and lithography, and etching There will be an approach (TOREWERA et al. and 1177 SPIE(s) 379 pages, 1989) using a photosensitive giant molecule or a resist in an electronics letter, 27 pages [1342], and 1991. In this, the approach of TOREWERA has the highest simplicity and is excellent also in mass-production nature.
[0005]
[Problem(s) to be Solved by the Invention] However, since the conventional sensitive material using

polymeric materials says that it is the property and solid-state which these polymeric materials have, the more it uses it as a thick film, the more the following troubles produce it. That is, dispersion in ultraviolet and a visible region is large, and it has faults, such as that a light transmission property deteriorates especially that the pattern dependability at the time of a thick film falls, that resolution falls when it hardens, and having a bad influence also on loss of the optical waveguide to produce. Moreover, since it is not considered in reduction of absorption loss of an ingredient etc. to transparency, it has the fault that optical waveguide loss is also high. For this reason, there was a field where the practicality of the optical components produced using the ingredient concerned is inadequate. Moreover, it also has another fault that the ingredient containing aromatic series radicals, such as the benzene ring for raising thermal resistance, has a large birefringence. This is for aromatic series radicals', such as a chain's, especially the benzene ring's, carrying out orientation within a thin film, and discovering optical anisotropy, when a giant-molecule thin film is formed using such an ingredient. For this reason, the optical waveguide produced using the ingredient concerned has the polarization dependency, and even if the reinforcement of incident light is fixed, those output characteristics will be changed by fluctuation of plane of polarization. Therefore, when actually using as optical waveguide of a single mode system especially, such a polarization dependency poses a problem. In order to cancel such a polarization dependency, it is necessary to use combining a polarizer etc. and there is a fault that the configuration of an optical device becomes quite complicated in fact.

[0006] Moreover, since it will become the form where it is overcome if irregular when making optical waveguide using polymeric materials, it becomes impossible to connect directly optical waveguide, an optical fiber or a light emitting device, and a photo detector. Therefore, after making each component separately, carrying out alignment, and connecting with a block, or making optical waveguide previously and carrying out alignment later, a policy, such as incorporating a luminescence photo detector, is needed, and the high cost of components[optical]-izing is caused.

[0007] therefore , this invention be made in view of the above-mentioned situation , have simple pattern organization potency , and be excellent in thermal resistance and moisture resistance , and a birefringence be small and aim at offer the ridge pattern formation approach of the giant molecule optical waveguide core section which be simple , be excellent in mass production nature , use liquefied reactivity oligomer excellent in workability , and can make connection with optical components easily .

[0008]

[Means for Solving the Problem] In order to solve the above-mentioned technical problem, therefore, the ridge pattern formation approach of the giant-molecule optical waveguide core section based on this invention The process which forms a sump pool in the part which is an approach for forming the ridge pattern corresponding to the core section of giant-molecule optical waveguide, and should form giant-molecule optical waveguide beforehand, The process which pours the liquefied photosensitive matter into this sump pool, and the process which carries out an optical exposure through the mask with which the predetermined ridge pattern was formed to the liquefied photosensitive matter poured into the sump pool, and forms a pattern latent image, It has the process which removes the non-irradiated part of the photosensitive matter using a solvent after this pattern latent-image formation, and is characterized by considering as the core section for light guiding further the part into which the photosensitive matter remained at the process of removal by the solvent.

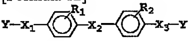
[0009] The process which forms preferably the slot which consists of one configuration of the V grooves or rectangle slots for installing an optical fiber in the both sides of a sump pool after the process which forms a sump pool beforehand, It has further the process which performs alignment of the liquefied photosensitivity matter poured in to the sump pool after the process which pours the liquefied photosensitive matter into a sump pool, and the optical fiber put on the slot, and optical connection of the core section is made with the core section of an optical fiber. Or the process which forms preferably the slot which consists of one configuration of the V grooves or rectangle slots for installing a microoptics component in the position of a sump pool after the process which forms a sump pool beforehand, It is good also as an approach of having further the process which performs alignment with the microoptics component placed after the process which pours the liquefied photosensitive matter into

a sump pool in the liquefied photosensitive matter, V groove, or rectangle slot accumulated in the sump pool, and making optical connection with the core section and a microoptics component. As for a microoptics component, in the case of the latter approach, what is chosen from the group which consists of laser diode (LD), light emitting diode (LED), light-receiving diode (PD), a filter, a lens, a mirror, a diffracted-light child, and a polarizing element is desirable.

[0010] In one of the above-mentioned approaches, the liquefied photosensitive matter is good also as what consists of reactant oligomer and a photopolymerization initiator. In this case, it is desirable that liquefied reactant oligomer is the oligomer compound expressed with the following general formulas (1) thru/or either of (5).

[0011]

[Formula 12]

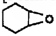

(1)

[0012] (Expressing the connection radical which R1 and R2 show a hydrogen atom, a halogen atom, an alkyl group, an alkoxy group, or a trifluoromethyl radical independently among a formula, respectively, and X1, X2, and X3 contain the alkyl group, the alkyl ether radical, and the ring, and contains the OH radical of a piece at least, Y is a polymerization active group and [0013].)

[Formula 13]

[0014] Or [0015]

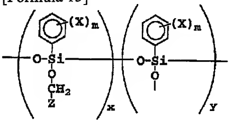
[Formula 14]



[0016] It is come out and shown.

[0017]

[Formula 15]


(2)

[0018] (X expresses a hydrogen atom, a heavy hydrogen atom, a halogen atom, an alkyl group, and an ARUKOSHIKI radical among a formula, and m expresses the integer of 1-4.) Z is an epoxy group shown in the following type (I) or (II), and is [0019].

[Formula 16]


(I)

[0020]

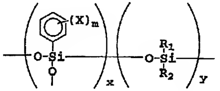
[Formula 17]


(II)

[0021] x and y may show the abundance of each unit among a formula, and y may be 0 smaller than x.

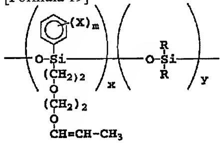
[0022]

[Formula 18]



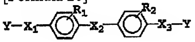
(3)

[0023] (X expresses a hydrogen atom, a heavy hydrogen atom, a halogen atom, an alkyl group, and an alkoxy group among a formula, and m expresses the integer of 1-4.) x and y show the abundance of each unit and x and y are not 0. R1 and R2 a methyl group, an ethyl group, and an isopropyl group -- expressing -- R1 R2 a phase -- it may be equal
[0024]
[Formula 19]



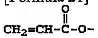
(4)

[0025] (X expresses a hydrogen atom, a heavy hydrogen atom, a halogen atom, an alkyl group, and an alkoxy group among a formula, and m expresses the integer of 1-4.) x and y show the abundance of each unit and x and y are not 0. R expresses a methyl group, an ethyl group, and an isopropyl group.
[0026]
[Formula 20]

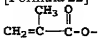


(5)

[0027] (R1 and R2 show a hydrogen atom, a halogen atom, an alkyl group, an alkoxy group, or a truffe ROORO methyl group independently among a formula, respectively, X1, X2, and X3 contain the alkyl group, the alkyl ether radical, and the ring, they express a connection radical, and Y is a polymerization active group [0028].)
[Formula 21]

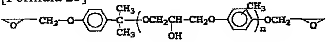


[0029]
[Formula 22]



[0030]) ******.
Here, the advantage of the photosensitive matter applied to this invention being liquefied reactant oligomer is described collectively.
[0031] (1) The condition before carrying out photo-curing is a liquid, and since homogeneity can be made high, it excels in ultraviolet and the light transmission property of a visible region, and even if the film hardened by optical exposure becomes thick, it has sufficient resolution.
[0032] (2) Since the condition before carrying out photo-curing is a liquid, even if there is a part which has irregularity, flattening is possible, and permeate everywhere, and the film formation corresponding to various configurations becomes easy.
[0033] (3) Since oligomer is connected at random and hardens, it is possible to make small form

birefringence of the ingredient at the time of hardening.
[0034]
[The example of a gestalt of implementation of invention] Hereafter, the macromolecule optical waveguide of this invention is explained to a detail based on the example of a gestalt of operation.
[0035] Macromolecule-ization of the epoxy system oligomer ingredient of this invention is performed by constructing a bridge by association by the light between the epoxy groups contained in the component expressed with a general formula (1) and (2). In order to make crosslinking reaction fully cause efficiently, it is desirable to add a photopolymerization initiator. Optical cationic initiators, such as sulfonium salt and an osmium salt, are raised as a typical thing that what is necessary is just what is generally used as a photopolymerization initiator as a photopolymerization initiator.
[0036] Moreover, macromolecule-ization of the silicone system oligomer ingredient of this invention is included also when based on the reaction of a sensitization agent and oligomer. As a sensitization agent, bis-azide compounds, such as azide compound [, such as an azide pyrene], 4, and 4'-diazido benzalacetone, 2, 6-G (4'-azide benzal) cyclohexanone, 2, and 6-G (4'-azide benzal)-4-methylcyclohexanone, and a diazo compound are typical.
[0037] Moreover, macromolecule-ization of the acrylic oligomer ingredient of this invention is based on the reaction of a sensitization agent and oligomer. As a sensitization agent, bis-azide compounds, such as azide compound [, such as azo compounds, such as peroxides, such as carbonyl compounds such as a diphenyl triketone benzoin, benzoin methyl ether, a benzophenone, an acetophenone, and diacetyl, and a benzoyl peroxide, and azobisisobutyronitril, and an azide pyrene], 4, and 4'-JIAZODO benzalacetone, 2, 6-G (4'-azide benzal) cyclohexanone, 2, and 6-G (4'-azide benzal)-4-methylcyclohexanone, and a diazo compound are typical.
[0038] When producing optical waveguide using the reactant oligomer ingredient according to this invention, the process can be performed as follows. namely, oligomer -- a substrate or clad top -- spreading or liquid -- an optical waveguide ridge pattern is formed by putting in useless, carrying out alignment and carrying out dissolution removal of Mitsuteru putting and the part which is not irradiated with a solvent through a mask. In this way, since the produced optical waveguide is excellent in solvent resistance, and it does not have orientation when macromolecule-izing, it can reduce a birefringence, therefore its polarization dependency is small, and it is low guided wave loss, and is excellent in thermal resistance and moisture resistance.
[0039]
[Embodiment of the Invention] Hereafter, although an example explains this invention still more concretely, this invention is not limited to these examples.
[0040] <Example 1> drawing 1 is a mimetic diagram for explaining each process of an example of the macromolecule optical waveguide pattern formation approach based on this invention.
[0041] The solution 10 containing the liquefied epoxy oligomer which has first the structure expression (1) shown below, and 2 % of the weight of photopolymerization initiators was prepared.
[0042]
[Formula 23]



(6)

[0043] (The inside of a formula, n= 1, 2 or 3) With a thickness of 100 micrometers epoxy resin 12a which has next the sump 11 with a depth [of 40 micrometers] x width-of-face [of 50mm] x die length of 50mm shown in drawing 1 (a) prepared the platform 12 formed on substrate 12b. The refractive index of this epoxy resin 12a was 1.52 on the wavelength of 0.85 micrometers.
[0044] This solution 10 was poured into the sump 11 of this platform 12 (drawing 1 (a)). The ultraviolet-rays (UV) light 14 was irradiated after solution impregnation through the mask 13 which has an optical waveguide pattern as shown on the platform 12 at drawing 1 (b) (drawing 1 (c)). under the present circumstances, UV light exposure -- 2000 mJ/cm2 it was . Then, when this sample was developed with the isopropanol solution, according to slit pattern 13a of a mask 13, liquefied epoxy

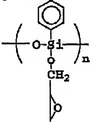
oligomer hardened only the optical exposure section, and the ridge pattern 15 of a configuration as shown in drawing 1 (d) has been produced. The refractive index after hardening was 1.535 on the wavelength of 0.85 micrometers. Then, the epoxy resin adjusted so that the refractive index at the time of photo-curing might be set to 1.52 to this ridge pattern 15 on the wavelength of 0.85 micrometers was applied and hardened, and optical waveguide was produced. The multimode channel optical waveguide 18 (depth width of face of 40 micrometers of 40 micrometers) which has the core section 17 which consists of a UV hardening epoxy resin of the refractive index of the clads 16 and 1.535 which consist of an epoxy resin of a refractive index 1.52 by this actuation was producible (refer to drawing 1 (e)). When this optical waveguide was started in die length of 5cm with the dicing saw and the insertion loss was measured, it was 3.0dB or less on 1.5dB or less and the wavelength of 1.55 micrometers in 1dB or less and 1.3 micrometers with the wavelength of 0.85 micrometers. Moreover, the polarization dependency of an insertion loss was also the wavelength of 1.3 micrometers, the wavelength of 1.55 micrometers, or 0.1dB or less. Furthermore, loss of this optical waveguide was not changed one month or more under the condition of 75 degrees C / 90%RH.

[0045] The channel optical waveguide for single modes (a depth of 8 micrometers, width of face of 8 micrometers, deltan0.3%) was produced using the sump 11 with a depth [of 8 micrometers] x width-of-face [of 50mm] x die length of 50mm using liquefied epoxy oligomer by the same approach as the <example 2> example 1. When this optical waveguide was started in die length of 5cm with the dicing saw and the insertion loss was measured, it was 3.0dB or less on 1.5dB or less and the wavelength of 1.55 micrometers in 1.3 micrometers. Moreover, as for the polarization dependency of an insertion loss, the wavelength of 1.3 micrometers or the wavelength of 1.55 micrometers was 0.1dB or less. Furthermore, loss of this optical waveguide was not changed one month or more under the condition of 75 degrees C / 90%RH.

[0046] By the same approach as the <example 3> example 1, the channel optical waveguide for single modes (a depth of 8 micrometers, width of face of 8 micrometers, deltan0.3%) was produced using the solution which adjusted the liquefied silicone epoxy oligomer expressed with the following structure expressions (2) and (molecular weight 2,000), and 2 % of the weight of photopolymerization initiators. When this optical waveguide was started in die length of 5cm with the dicing saw and the insertion loss was measured, it was 1.5dB or less on 1.0dB or less and the wavelength of 1.55 micrometers in 1.3 micrometers. Moreover, as for the polarization dependency of an insertion loss, the wavelength of 1.3 micrometers or the wavelength of 1.55 micrometers was 0.1dB or less. Furthermore, loss of this optical waveguide was not changed one month or more under the condition of 75 degrees C / 90%RH.

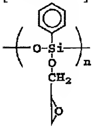
[0047]

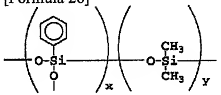
[Formula 24]



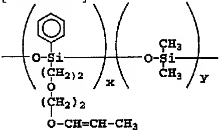
(7)

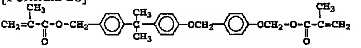
[0048] By the same approach as the <example 4> example 1, the channel optical waveguide for multimodes (a depth of 40 micrometers, width of face of 40 micrometers, deltan1%) was produced using the solution which adjusted the liquefied silicone epoxy oligomer expressed with the following structure expressions (2) and (molecular weight 2,000), and 2 % of the weight of photopolymerization initiators. When this optical waveguide was started in die length of 5cm with the dicing saw and the insertion loss was measured, it was 1.0dB or less on 1.0dB or less and the wavelength of 1.30 micrometers in 0.85 micrometers. Moreover, as for the polarization dependency of an insertion loss, the wavelength of 0.85 micrometers or the wavelength of 1.3 micrometers was 0.1dB or less. Furthermore, loss of this optical waveguide was not changed one month or more under the condition of 75 degrees C / 90%RH.

[0049]
[Formula 25]

(8)

[0050] By the same approach as the <example 5> example 1, the channel optical waveguide for single modes (a depth of 8 micrometers, width of face of 8 micrometers, deltan0.3%) was produced using the solution which adjusted the liquefied silicone oligomer expressed with the following structure expression (3) and (molecular weight 3,000), and 2 % of the weight of photopolymerization initiators.
[0051]
[Formula 26]

(9)

[0052] (The inside of a formula, x:y=7:4) When this optical waveguide was started in die length of 5cm with the dicing saw and the insertion loss was measured, it was 3.0dB or less on 1.5dB or less and the wavelength of 1.55 micrometers in 1.3 micrometers. Moreover, as for the polarization dependency of an insertion loss, the wavelength of 1.3 micrometers or the wavelength of 1.55 micrometers was 0.1dB or less. Furthermore, loss of this optical waveguide was not changed one month or more under the condition of 75 degrees C / 90%RH.
[0053] The optical waveguide for multimodes (a depth of 40 micrometers, width of face of 40 micrometers, deltan1%) was produced by the same approach as an example 1 using the same liquefied silicone oligomer as the next. When this optical waveguide was started in die length of 5cm with the dicing saw and the insertion loss was measured, it was 1.0dB or less on 0.55dB or less and the wavelength of 1.55 micrometers in 1.0dB or less and 1.3 micrometers with the wavelength of 0.85 micrometers. Moreover, the polarization dependency of an insertion loss was 0.1dB or less. Furthermore, loss of this optical waveguide was not changed one month or more under the condition of 75 degrees C / 90%RH.
[0054] The optical waveguide for multimodes (a depth of 40 micrometers, width of face of 40 micrometers, deltan1%) was produced by the same approach as an example 1 using the solution which adjusted the liquefied silicone vinyl ether oligomer expressed with the following structure expression (4) and (molecular weight 3,000), and 2 % of the weight of photopolymerization initiators by the same approach as the <example 6> example 1. When this optical waveguide was started in die length of 5cm with the dicing saw and the insertion loss was measured, it was [the following and] 1.0dB or less on the wavelength of 1.55 micrometers in 0.5dB with 1.0dB or less and the wavelength of 1.3 micrometers at the wavelength of 0.85 micrometers. Moreover, the polarization dependency of an insertion loss was 0.1dB or less. Furthermore, loss of this optical waveguide was not changed one month or more under the condition of 75 degrees C / 90%RH.
[0055] The channel optical waveguide for single modes (a depth of 8 micrometers, width of face of 8 micrometers, deltan0.3%) was produced using the ingredient still more of the same kind. When this optical waveguide was started in die length of 5cm with the dicing saw and the insertion loss was measured, it was 3.0dB or less on 1.5dB or less and the wavelength of 1.55 micrometers in 1.3 micrometers.

[0056]
[Formula 27]

(10)

[0057] (The inside of a formula, x:y=1:1)
The solution which adjusted the liquefied acrylic oligomer which has the structure expression (5) shown below in <the example 7>, and 2 % of the weight of photopolymerization initiators was prepared.
[0058]
[Formula 28]

(11)

[0059] Next, optical waveguide was produced by the same approach as examples 1 and 2.
[0060] When the produced optical waveguide for multimodes (delta with depth [of 40 micrometers] and a width of face of 40 micrometers n 1%) was started in die length of 5cm with the dicing saw and the insertion loss was measured, it was 5.0dB or less on 0.5dB or less and the wavelength of 1.55 micrometers in 1.0dB or less and 1.3 micrometers with the wavelength of 0.85 micrometers. Moreover, as for the polarization dependency of an insertion loss, the wavelength of 1.3 micrometers or the wavelength of 1.55 micrometers was the following in 0.1dB. Furthermore, loss of this optical waveguide was not changed one month or more under the condition of 75 degrees C / 90%RH. Loss of the optical waveguide for single modes (a depth of 8 micrometers, width of face of 8 micrometers, deltan0.3%) was 1.55 micrometers or less in 0.5dB or less and wavelength in 1.3 micrometers. Moreover, as for the polarization dependency of an insertion loss, the wavelength of 1.3 micrometers or the wavelength of 1.55 micrometers was 0.1dB or less.
[0061] The solution 20 which adjusted the liquefied epoxy oligomer used in the <example 8> example 1 and 2 % of the weight of photopolymerization initiators was prepared.
[0062] Next, as shown in drawing 2 (a), it has the sump 21 with a depth [of 40 micrometers] x width-of-face [of 50mm] x die length of 50mm, and the epoxy resin with a thickness of 100 micrometers with which the semiconductor laser light source 22 (oscillation wavelength of 0.85 micrometers) and an electric eye 23 faced, and have been arranged on both sides of the sump prepared the platform 24 formed on the substrate. The depth of the luminescence side 22 is [2x5 micrometers and the light-receiving sides 23 of luminescence area] 50phimum in 80 micrometers from a substrate top face. The core of light-receiving and luminescence is united with a depth of 80 micrometers from the substrate. The refractive index of this epoxy resin was 1.52 on the wavelength of 0.85 micrometers. Next, the solution 20 was poured into the sump 21 (drawing 2 (a)). Under the present circumstances, the amount of the solution 20 to pour in was controlled and the UV light 26 was irradiated after that throughout a period of mask which has optical waveguide pattern as shown in drawing 2 (b) 25 (drawing 2 (c)). an exposure -- 2000 mJ/cm2 it was . Then, when this sample was developed with the isopropanol solution, according to ridge pattern 25a of a mask 25, liquefied epoxy oligomer hardened only the optical exposure section, and the ridge pattern 27 of a configuration as shown in drawing 2 (d) has been produced. The refractive index after hardening was 1.535 on the wavelength of 0.85 micrometers. Then, the refractive index applied 1.52 epoxy resins to this ridge pattern on the wavelength of 0.85 micrometers, and optical waveguide was produced. The optical waveguide device
[INTAKONEKUTO / the channel optical waveguide 29 (a depth of 45 micrometers, width of face of 45

micrometers, deltan1%) which has the core section 27 which consists of epoxy UV hardenability resin of the refractive index of the clads 28 and 1.535 which consist of an epoxy resin of a refractive index 1.52 by this actuation / optical waveguide device / the optical transceiver device] 200 was producible (drawing 2 (e)). When light was introduced from this optical waveguide 22, 0.5dB of joint loss and the joint loss by the side of light-receiving were about 0.5dB.

[0063] The epoxy resin with a thickness of 100 micrometers which has the sump 32 with a depth [of 40 micrometers] x width-of-face [of 50mm] x die length of 50mm which has the slot 31 with a depth [of 100 micrometers] x width-of-face [of 20 micrometers] x die length of 20mm into a central part as shown in <example 9> drawing 3 (a) prepared the platform 33 formed on the substrate. The refractive index of this epoxy resin was 1.52 on the wavelength of 0.85 micrometers. Next the wavelength filter 34 (filter which penetrates only the wavelength of 0.85 micrometers) was injected into the slot on 31, and the liquid 10 of an example 1 was poured into the sump 31. Under the present circumstances, the amount of the liquid 10 to pour in is having the precision controlled. Then, the UV light 36 was irradiated throughout a period of mask which has optical waveguide ridge pattern as shown in drawing 3 (b) 35 (drawing 3 (c)). an exposure -- 2000 mJ/cm2 it was . Then, when this sample was developed with the isopropanol solution, according to slit pattern (ridge pattern) 35a of a mask 35, liquefied epoxy oligomer hardened only the optical exposure section, and the ridge pattern 37 of a configuration as shown in drawing 3 (d) has been produced. The refractive index after hardening was 1.535 on the wavelength of 0.85 micrometers. The epoxy resin adjusted so that a refractive index might be set to 1.52 on the wavelength of 0.85 micrometers after that was applied. The channel optical waveguide with a wavelength filter which has the core section 39 which consists of a UV hardening epoxy resin of the refractive index of the clads 38 and 1.535 which consist of a UV hardening epoxy resin in which the refractive index 1.52 carried out photo-curing by this actuation, and the wavelength separation components 300 (depth width of face of 45 micrometers of 45 micrometers, deltan1%) were producible (drawing 3 (e)). As for 0.85-micrometer light, the wavelength separation property which carries out outgoing radiation was enough shown in this optical waveguide from the port 2 of a reference mark 302 in light (0.85 micrometers and 1.3 micrometers) more nearly again than the port 1 of a reference mark 301 at ****** and the time, as for 1.3-micrometer light. The isolation of 1.5dB of insertion losses and wavelength was about 40dB with 0.85-micrometer band.

[0064] As shown in <example 10> drawing 4 (a), the epoxy resin with a thickness of 100 micrometers which has the sump 42 with a depth [of 40 micrometers] x width-of-face [of 50mm] x die length of 50mm which has the crevice 41 with a depth [of 100 micrometers] x width-of-face [of 126 micrometers] x die length of 5mm in both ends prepared the platform 43 formed on the substrate. The refractive index of this epoxy resin was 1.52 on the wavelength of 0.85 micrometers. Next the optical fiber 44 (125-micrometer outer diameter, core diameter of 50 micrometers) was poured into the crevice of a reference mark 41, and it fixed with adhesives (drawing 4 (b)). Next, the liquid 10 of an example 1 was poured into the sump 42. Under the present circumstances, the injection rate of liquid 10 is controlled by the precision. Then, the UV light 46 was irradiated throughout a period of mask which has optical waveguide ridge pattern 45a as shown in drawing 4 (c) 45 (drawing 4 (d)). an exposure -- 2000 mJ/cm2 it was . Then, when this sample was developed with the isopropanol solution, according to ridge pattern 45a of a mask 47, liquefied epoxy oligomer hardened only the optical exposure section, and the ridge pattern 48 of a configuration as shown in drawing 4 (e) has been produced. The refractive index after hardening was 1.535 on the wavelength of 0.85 micrometers. Then, photo-curing of the epoxy resin adjusted so that a refractive index might be set to 1.52 on the wavelength of 0.85 micrometers was applied and carried out. The channel optical waveguide 401 (depth width of face of 45 micrometers of 45 micrometers, deltan1%) with an optical fiber which has the core section 400 which consists of a UV hardening epoxy resin of the refractive index of the clads 49 and 1.535 which consist of an epoxy resin of a refractive index 1.52 by this actuation was producible (drawing 4 (f)). When light (0.85 micrometers and 1.3 micrometers) was introduced into this optical waveguide, outgoing radiation of the 0.85-micrometer light was carried out from the optical fiber 44, and that insertion loss was about 1.5dB.

[0065] In addition, instead of liquefied epoxy oligomer, even if it used the liquefied silicone epoxy

oligomer of this invention, liquefied silicone oligomer, and liquefied silicone vinyl ether oligomer, the components which have an example 8 thru/or the engine performance equivalent to 10 were producible.
[0066] When the diffraction grating 50 as shown in drawing 5 instead of the wavelength plate used in the <example 11> example 9 was inserted, the same wavelength separation component as an example 9 was produced and light (0.85 micrometers and 1.3 micrometers) was introduced, 0.85 micrometers light and 1.3-micrometer light were separated, and the isolation of 1.5dB of insertion losses and wavelength was able to produce the about 40dB wavelength separation component with 0.85-micrometer band.
[0067] When the half mirror 60 as shown in drawing 6 instead of the wavelength plate used in the <example 12> example 9 was inserted, the branching component which has the same configuration as an example 9 was produced and the light of 0.85 micrometer** was introduced, 0.85-micrometer light was able to branch and was able to produce 1.5dB of insertion losses, and the branching component of a branching ratio 1:1.
[0068] The polarizing element 70 as shown in drawing 7 instead of the wavelength plate used in the <example 13> example 9 was inserted, and the polarization separation component which has the same configuration as an example 9 was produced. However, it is made the optical waveguide item which is satisfied with 1.3 micrometers of single mode conditions in this case. Specifically, the core sections are 8x8 micrometers and 0.2% of refractive-index differences. When the 1.3-micrometer circular polarization of light was introduced, from the port 1 of the reference mark 71 of drawing 7 , the TE mode carried out outgoing radiation of the light, and only the TM mode was carrying out outgoing radiation from the port 2 of a reference mark 72. The isolation was 30dB or more.
[0069] It was possible to insert a lens 81 by the approach same with having inserted the wavelength plate for receiving the light from LED80 at the example 9, as shown in <example 14> drawing 8 , and to have produced the multimode optical waveguide 82 with a lens. Joint effectiveness improved by about 10dB compared with the case where there is no lens 81.
[0070]
[Effect of the Invention] As explained above, by using a reactant oligomer ingredient, simply, the ridge pattern formation approach of the giant-molecule optical waveguide core section of this invention is excellent in thermal resistance and moisture resistance, and its birefringence is small and it can form the giant-molecule optical waveguide pattern with which connection with optical components is made easily. Moreover, an optical waveguide ridge pattern with a steep and smooth wall surface can be formed by hardening the film by optical exposure and developing negatives with a suitable solvent. Moreover, optical waveguide processing of the ridge pattern formation method using the conventional giant molecule is easily attained with a thick film to thick-film formation and optical waveguide processing being very difficult. Furthermore, to having had the big birefringence for the orientation of a chain, with the photo-curing object of the liquefied oligomer of this invention, this birefringence is reduced by 1x10 to three or less, and the conventional aromatic series content macromolecule thin film by which the heat-resistant design was carried out becomes possible [reducing a polarization dependency below to an allowed value] by the optical waveguide by the ingredient concerned. In addition, this optical material can acquire the suitable viscosity corresponding to the formation process of a thin film by adjustment of molecular weight.
[0071] Therefore, this invention is applicable to the various optical waveguides which are general optics and the microoptics field and are used in the field of optical communication or optical information processing, an optical integrated circuit, or an optical patchboard.

[Translation done.]